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EXPLOSIONS OF COAL DUST IN TIPPLES AND CLEANING PLANTS AND SOME SUGGESTIONS ON PREVENTING THEM

BY

W. J. FENE AND C. W. OWINGS

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EXPLOSIONS OF COAL DUST IN TIPPLES AND CLEANING PLANTS AND SOME SUGGESTIONS ON PREVENTING THEM 1/

By W. J. Fene 2/ and C. W. Owings 3/

INTRODUCTION

Generally, the hazard of coal-dust explosions in tipples and cleaning plants is not given the consideration that is given it underground. This lack of consideration is probably due to failure to appreciate the potential hazard. An explosion in a tipple or cleaning plant is basically little or no different from an explosion underground. If bituminous-coal dust is raised into a cloud in the air and comes in contact with arcs from motor brushes, switches, or open flame, the dust is very likely to ignite, and flame will very probably propagate or extend through it if the quantity of dust per unit of air space is sufficient. The open space in a tipple or cleaning plant may reduce the violence of the explosion, but it is not likely to prevent ignition or propagation of flame.

The movement of coal through a tipple or cleaning plant naturally puts into suspension a large amount of dust, which finally settles on exposed surfaces. Any disturbance that will put this dust into suspension in a sense enough cloud can result in the dust being ignited by an arc or open flame if one should be present. An explosion of bituminous-coal dust in a tipple or cleaning plant generally can be prevented either by keeping it thoroughly clean or by removing all sources of ignition, or both.

The tests at the U.S. Bureau of Mines Experimental mine have shown that the explosibility of coal dust is proportional (other things being equal) to the ratio of the volatile matter to the volatile matter plus the fixed carbon, indicated thus:

$$\frac{\text{Volatile}}{\text{Volatile + fixed carbon}} = \text{Volatile ratio.}$$

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The volatile ratio for the Pittsburgh coal bed is calculated as follows:

$$\text{Volatile ratio} = \frac{\text{Volatile}}{\text{Volatile + fixed carbon}} = \frac{38.6}{38.6 + 55.6} = 0.409.$$

Therefore, as the volatile matter decreases the liklihood of ignition decreases; however, coal-dust explosibility depends on other factors also, such as fineness, dryness, and cloud density; and under some conditions other factors also intervene.

Proof of the explosibility of coal dust in the absence of explosive gas has been shown in numerous cases in mines and mine plants and also by a series of tests. In these tests a dense cloud of dust is blown onto an open flame or an electric arc, almost invariably with resultant exploding of the dust. The Safety Division of the United States Bureau of Mines has made a number of demonstrations of the explosibility of Pittsburgh coal-bed dust, using a small gallery or box in which a cloud of coal dust is blown onto a lighted match; larger-scale tests have been made with an electric arc as the igniting agent. Bituminous-coal dust is readily ignited with a medium arc, but with low-volatile coals a larger arc is required. For test purposes, a 100-ampere arc has been used. Ignition has occurred readily under these conditions with Pocahontas No. 5 coal dust with ratios of volatile to total combustible of 0.232 to 0.253, and with Pocahontas No. 3 coal dust with a combustible ratio of 0.242. Lower Kittanning coal dust, with a ratio of 0.187, did not give definite ignitions, and Pocahontas No. 4 dust did not explode, although part of the coal-dust cloud ignited. It is probable that even the low-volatile coal dust will be found to be explosive with a higher-amperage electric arc as the initiating agent.

Gathering locomotives employing contactors instead of the regular-type controllers have been found to ignite coal dust that worked into the contactor compartment; a somewhat similar condition may exist in tipples and cleaning plants, where open-type electric motors are employed. At least on instance is on record of an explosion of anthracite dust in a breaker in the Pennsylvania anthracite district; this occurrence is unusual because anthracite dust normally is difficult to explode. Probably the dust was exceptionally finely divided; even some metals, such as zinc and aluminum, very finely divided, oxidize so rapidly in the presence of flame that an explosion occurs; therefore, it is by no means impossible for even anthracite dust to explode. Unquestionably, adequate precautions should be taken to prevent coal-dust accumulations in both bituminous and anthracite surface buildings.

CASES OF EXPLOSIONS IN TIPPLES AND CLEANING PLANTS

A number of coal-dust explosions have occurred in tipples and cleaning plants in the United States, some of which resulted in fatalities, injuries, and damage to property. A few selected cases of such explosions are cited:

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Case 1

Three men were engaged in some remodeling work in the headhouse, requiring the cutting of an I-beam with an acetylene torch. Considerable fine dust had accumulated within the headhouse, and the foreman had instructed the men to sweep down the dust before beginning to work on the remodeling. When the I-beam was cut, it and the old weigh-pan fell about 12 feet onto the coal in the bin. The entire structure was shaken, and fine dust was dislodged in a dense cloud and was ignited by the flame of the torch. There were several "flamings" as the various dust clouds were ignited, and the flames extended about 40 feet in height, enveloping the entire chute.

One of the men fell prone, covering his face with his hands, and received only slight burns. Another, on the track about 20 feet above the chute, received burns on the face and hands. The man using the torch was burned severely.

This is the second experience of this kind suffered by this company. Two men were severely burned in a coal-dust explosion in a tipple at another mine about 3 years previous.

Case 2

A railroad-car dropper and a car trimmer received second-degree burns when a loose lead to a coal-crushing motor caused an arc that ignited suspended coal dust in the crusher house.

Case 3

A trip of cars broke away at the head of the incline and crashed into the tipple. The resulting dust cloud was ignited by an upset heating stove. No injuries were sustained.

Case 4

An arc from an open motor ignited coal dust within the shaker-drive house and burned one man slightly. Brattice cloth had been hung in the open parts of the tipple to protect the workmen from the weather. This cloth was ignited, and some of the metal sheeting was blown off the tipple by the explosion. Prompt action saved the tipple and perhaps the mine from being consumed by fire, as a wood and sheet-iron snow-shed, 500 feet long, connected the tipple and mine.

A permissible-type motor was installed after this explosion, and the tipple has since been kept free of dust.

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Case 5

Some repairs were being made in the headframe of a tipple, and an acetylene torch was being used. An I-beam that was being removed dropped and dislodged fine coal dust, which was ignited by the torch. Five men were burned severely and three others slightly; a large part of the tipple siding was blown off.

Case 6

A chute full of slack coal under a tipple fell on a larry trolley wire, causing an arc that ignited the dust cloud thrown into suspension by the fall of the chute. The flame enveloped the tipple and slightly burned several men.

Case 7

Some remodeling was being done in a dry-cleaning plant and a section of metal air duct was being removed. All of the structural work around the location where this work was being done had previously been washed down with water. An acetylene torch was being used to sever the last two rivets securing the metal section 6 feet wide by 12 feet long by 14 feet high. C-clamps were used to hold the section, but when all the rivets had been removed the C-clamps failed to hold the section in place and it fell several feet. The man who was cutting the rivets with a torch was standing on a support about 30 feet above the floor when the metal section fell. The fall jarred the overhead duct and dislodged fine coal dust from it. The dust came in contact with the torch and was ignited. The flame enveloped the man using the torch, ignited his clothing and burned him severely.

Case 8

A rather unusual ignition of coal dust occurred under a slack-coal bin while a larry was preparing to transport a load of slack to beehive-coke ovens. In filling the larry the slack coal frequently ran over the side and onto the track. This overflow slack accumulated over the rails and caused arcing at the wheels when power was applied to move the larry.

On the trip when the coal dust was ignited, the usual practice had been followed - that is, the larry had been filled to overflowing. When the controller was moved to the third point there was a jarring of the larry, which shook off more of the fine coal and created a dust cloud that enveloped the larry. This dust cloud was ignited by an arc at the wheels. The flame enveloped the larry and the operator, who was standing at the footboard at the controls. He received severe burns on the hands, forearms, face, and neck.

Case 9

The superintendent of a coal mine was looking out of his office window at the tipple at about 7:30 one morning when, suddenly, he saw a flash and

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heard a detonation. Immediately afterwards he saw the wooden sides of the tipple blown outward. At the time of the accident the night coal was being dumped, and a dense cloud of dust was in suspension. The carbide lamp worn by one of the men ignited the coal dust and exploded it. Two men were burned but, fortunately, no lives were lost.

The coal was from the Pittsburgh bed, which is known to be readily explosive; many mining men doubt that coal dust from this bed can be ignited by the flame of a carbide lamp, but this fact has been demonstrated in a small gallery.

Lessons Learned

The lessons to be learned from these explosions are:

1. Bituminous-coal dust is explosive when a sufficiently dense cloud of it is brought into contact with an open flame, such as a blow torch, carbide lamp, acetylene torch, electric arc, or coal-stove fire.

2. When repairs are to be made in a surface or underground structure at a coal mine, coal dust should be removed from places where torches or electric welders are to be used.

3. When metal parts of a tipple or cleaning plant are to be cut with a torch, they should be clamped in place firmly or so supported that the parts will not be jarred or fall when cut apart.

4. Open coal stoves should be prohibited on tipples and in cleaning plants.

5. Open electric-resistance-type heaters should be prohibited in coal tipples and cleaning plants.

6. Open-type electric motors and equipment should not be used in coal tipples and cleaning plants.

7. Electric light bulb covers of the "vaporproof" type should be used in dusty locations.

8. Coal dust should be kept from tracks on which electric locomotives or slate larries travel.

9. Only permissible electric equipment should be used in and around coal mines. It should be grounded adequately and protected by proper fuses or circuit breakers in each circuit.

10. Coal dust should be removed from all surfaces in tipples and cleaning plants at the end of each work shift.

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The foregoing relatively few of the available instances of explosion of fine coal dust in tipples and cleaning plants clearly demonstrate what might easily happen in many such plants in this country. Remedial measures to prevent such explosions obviously are the elimination of the dust and of sources of ignition. The elimination of sources of ignition can be accomplished in large part by installing permissible motors and enclosed switches with approved wiring and by prohibiting open flames within the structures. The accumulation of coal dust may be avoided either by frequent thorough cleaning to remove the dust from all surfaces or by removing the dust as it is put into suspension, or a combination of the two methods.

CONTROL OF DUST

The coal-dust hazard may be eliminated by "killing" the dust at its source or by removing it after it has settled. Wherever possible, the amount of dust in a coal mine should be reduced by using water on the cutter bar of mining machines, sprinkling the broken-down coal before loading, and wetting the top of each loaded car before it starts for the outside, as well as wetting the empty car after it has been dumped. If this cannot be done in conjunction with wetting at the face, the coal may be wetted while it is being dumped by means of a strong curtain spray of water. Such installations are suitable for underground dumps as well as on surface dumps in certain climates or during nonfreezing weather. The control of dust at certain underground dumps was described in Coal Age, vol. 29, pp. 753-756, How Mines with Underground Dumps are Trying to Eliminate Coal-Dust Hazard, by C. W. Owings and V. C. Allison.

Where it is inadvisable to use water, the dump may be covered with a hood and the dust exhausted by an air current induced by a properly-designed fan; the dust-laden air should discharge into a cyclone, bag, or other effective type of separator.

So-called dedusters have been used to remove dust from coal; they operate as follows: The coal is dropped into the top of the deduster and allowed to fall in a thin stream. Air is forced inside of the falling coal stream and passes through the coal, removing approximately minus 10-mesh dust. Generally the exhaust is passed to a dust collector. Coal 3/8-inch and under is generally fed to such a device. The effective removal of dust from coal requires preliminary sizing; during this period considerable dust may be expelled into the air unless adequate precautions against it are taken. The dump, if on the tipple, should be covered with a hood which is as tight as possible, and at least the first set of screens should be covered with a hood in which is an opening or openings for air pipes or ducts. The dust may then be drawn into a suitable collector. Although it is advisable to cover all conveyors with tight hoods, this is not always feasible. After the small sizes of coal have been removed, hoods are not always needed; in fact, they are a handicap where men must pick impurities from the coal.

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The success of dust collection depends largely upon suitable air velocities and filters. Dust-collecting systems used in coal plants are largely cyclone collectors or screen-and/or bag-filter types. The first essential is to enclose in tight hoods all equipment that produces objectionable dust. The dust created in the dumping, cleaning, and conveying operations is then removed by air, which should have a velocity of 3,500 to 4,000 feet per minute. To obtain satisfactory results, the type of inlet openings, size, and arrangement of pipes must be carefully designed and calculated. The system may be the pressure type, in which the dust-laden air passes through the fan before it reaches the collector; or it may be the exhaust type, in which the dust is removed from the air before the air stream passes through the fan. The exhaust system is usually preferred for coal plants.

The cyclone collector consists of a cylindrical section superimposed on a cone. The dust-laden air is carried into the cylindrical section by a horizontal pipe joined to the section tangentially. The sudden expansion of the air in the larger area of the cyclone, combined with centrifugal action, reduces the velocity of the air and allows the heavier particles to drop into the bottom of the cone. The air outlet is at or near the top of the cyclone and, having a larger area than the inlet pipe, reduces the velocity to one fourth or even one eighth of the inlet velocity. Many coal dusts are composed partly of impalpably fine dust that will not settle readily; consequently, large clouds of coal dust may at times be seen issuing from the cyclone.

The cloth dust filter is capable of collecting most of the fine dust below 100-mesh. This type of collector generally consists of a steel housing or case in which filters are placed. The filters are bags made of suitable material to filter out the dust. The bags are placed in a rack; and the top is left open, but the top edges of the bags are so placed that they form a tight seal on the sides. The housing is generally so large that there is expansion room, reducing the air velocity and allowing the coarser dust to settle in the hoppers. The dust-laden air impinges against the outside of the bags (of which there is a varying number, depending on the amount of dust to be removed from the air), and the air then passes into the inside of the bags and out of the top into the outlet air duct. The cleaned air is then expelled to the outside of the plant. The seals at the top of the bags prevent dust from passing between two adjacent bags and into the outlet at the top or side of the section. To maintain the efficiency of the filters, the bags are shaken by various means, such as jarring the frames or striking with beaters and similar devices. The value of such devices is often decreased by faulty covering of equipment that produces dust.

In most coal dry-cleaning plants considerable dust is usually found on all surfaces. Consequently it is generally necessary to clean tipples and cleaning plants daily if the coal-dust explosion hazard is to be eliminated.

The most prevalent method used to remove dust from tipples is to sweep it into piles and then remove it, or possibly sweep it through cracks and

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openings in the tipple floor. The latter practice is hazardous because it tends to raise dense clouds into suspension and thereby may cause an explosion if an igniting agency should intervene. The use of open-type (generally makeshift) stoves in winter to keep tipple employees warm makes sweeping undesirable unless very carefully done; and the presence of open grid electric heaters, open-type electric motors, and other open-type electrical equipment makes it even more dangerous.

Removal of dust by using a hose from which water issues at considerable pressure is a more or less common method of cleaning coal tipples; this method is impracticable during cold weather and, if electric wiring or electrical equipment is installed in the tipple, a shock hazard exists, and such equipment may be damaged by the water. It has been suggested that permissible motors be used, thereby preventing entrance of water into the compartments if the motors and appurtenances are kept in first-class repair; that the equipment be covered with waterproof tarpaulins, canvas, or metal hoods; that wiring be placed in conduits; and that all power be cut off from the tipple during the cleaning process. These precautions are helpful but they do not solve the problem. It has also been suggested that motors be cleaned by blowing the dust from them with compressed air. However, this method raises the dust into a cloud, and it may be ignited. An explosion that resulted from this practice is described by L. D. Tracy in United States Bureau of Mines Bulletin 242, Explosion Hazards from the Use of Pulverized Coal at Industrial Plants.

Probably one of the most satisfactory methods of removing dust from coal tipples and cleaning plants is by the use of a vacuum cleaning system; this has been found to be effective and at least fairly practical. It is also adaptable to many conditions. The hose allows the operator to move freely into places difficult of access by other means. The various types of tools or nozzles allow the operator to clean the floor, sides of buildings, and equipment and to reach tops and sides of girders, angle irons, and similar parts of the building.

Two types of vacuum cleaning systems are used. One is the portable type, consisting of an electric motor, an exhauster (generally of the centrifugal type), a dust collector, and one or more lengths of hose. The portable unit is satisfactory where there are no stairs or more than one floor to clean; however, the portable type is not altogether satisfactory for coal tipples and cleaning plants.

The stationary system is better adapted to coal plants. A carefully designed layout can be used. Vacuum pipes are installed throughout the plant, and suitable connections for the hose are made at convenient points. Such systems are generally designed so that three men may work simultaneously. The dust is drawn through the pipes to one or more collectors or separators. A common arrangement is to have two separators. The first is generally of the cyclone or modified cyclone type, which causes the heavier dust to settle

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to the bottom. The outlet air, carrying the fine dust, passes to the second collector, which usually has a bag or cloth filter. The exhaust or cleaned air then passes to the exhauster, which is usually of the centrifugal type.

The application of relatively tight covering to an underground dump and transfer points is illustrated by the installation at the Stotesbury (W.Va.) mine of the Koppers Coal & Transportation Co. Complete control is effected (see Coal Age, vol. 41, pp. 111-112) by enclosing the underground dump and two transfer points. The hoods are connected to a portion of a suction or vacuum duct connected to a blower installed in the tipple. The main 30-inch duct is suspended from the top in the slope. The 100-foot-long 30-inch pressure duct leads to a cyclone collector, which has a capacity of 15,000 cubic feet of air per minute. Approximately 125 pounds of coal dust is collected for each 1,000 tons of coal dumped. This dust is loaded with the slack.

CONCLUSIONS

The relatively few cases of explosion of coal dust in tipples and cleaning plants cited in this paper indicate the hazard of coal dust in such plants. Since it is usually impossible to prevent the release of fine coal dust in handling coal through a tipple or cleaning plant, it is imperative or at least very desirable that some means be employed to prevent dust accumulations or to eliminate all sources of flame if dust ignitions and explosions are to be avoided.

Many coal handling and cleaning plants have operated throughout their existence without a dust explosion, just as have many coal mines; however, the lack of explosions in very many installations was due to the lack of the combination of circumstances necessary to initiate an explosion, rather than to precautionary measures. And the fact that immunity from coal-dust explosions in mines or mining plants has been enjoyed for a long time is no reason for believing that this will always be so. It is far better to take reasonable precautions to prevent dust from igniting or exploding than to be forced to take them after a serious accident or disaster has occurred.

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